Modeling the scale of Population Connectivity

National Parks – Caribbean marine reserves' research and monitoring workshop

Robert K Cowen

Claire B. Paris

Ashwanth Srinivasan

UNIVERSITY OF MIAMI
RSMAS
ROSENSTIEL SCHOOL OF MARINE & ATMOSPHERIC SCIENCE

*What is **connectivity**?*

In the population context, ***connectivity*** is the measure of the rates of exchange of individuals among sub-populations.

For most marine organisms, **population connectivity** is largely driven by processes that influence **larval dispersal**

Fundamental question: “Over what spatial scales are marine populations connected via dispersal of early life stages?”

Population Connectivity

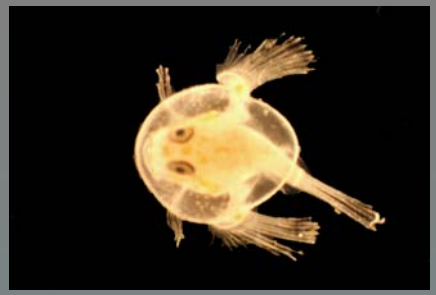
Most marine organisms have complex life cycles

Larval supply driven by:

- Production of eggs – ***f*** (adult population size)
- Larval survival – ***f*** (food, predation)
- Larval transport – ***f*** (currents, behavior, habitat)

Larval transport contributes to:

- Population variability (time and space)
- Population persistence
- Population dynamics (scaling)

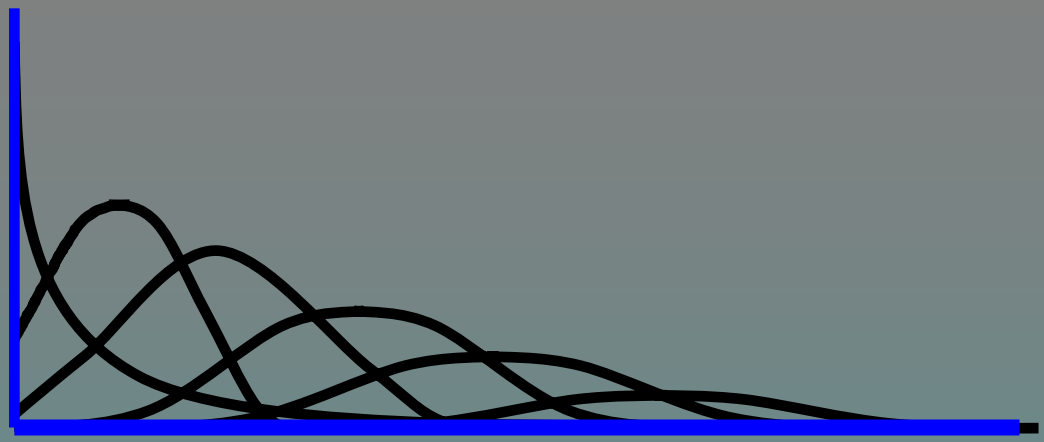


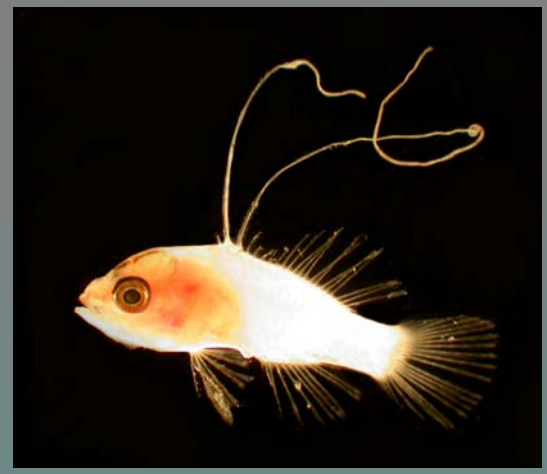

Over what scales does larval transport occur?

Evolutionary *vs*. Ecological

Evolutionary – a few individuals per generation required for genetic homogeneity

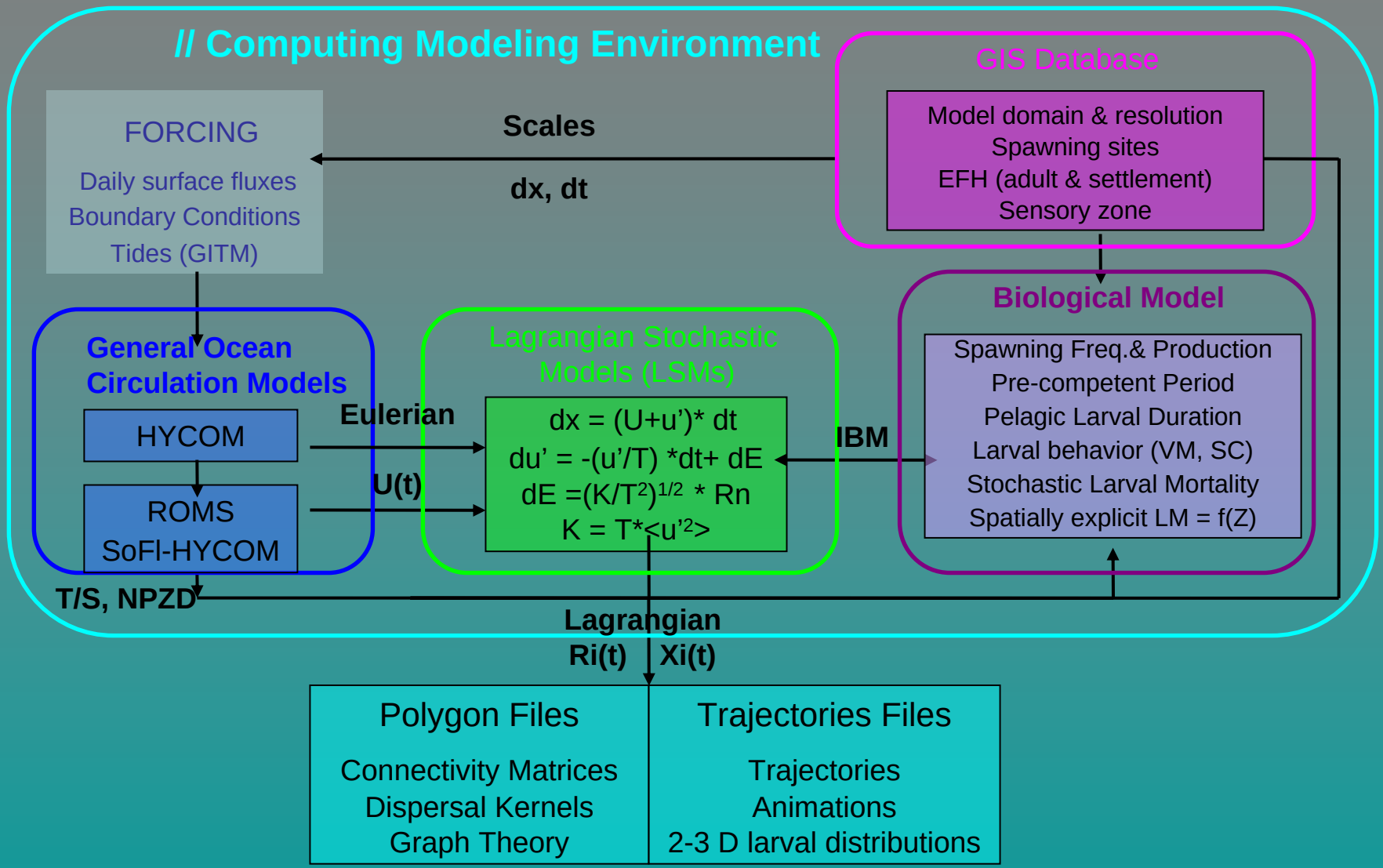
Ecological – many orders of magnitude – enough to replenish population's annual losses



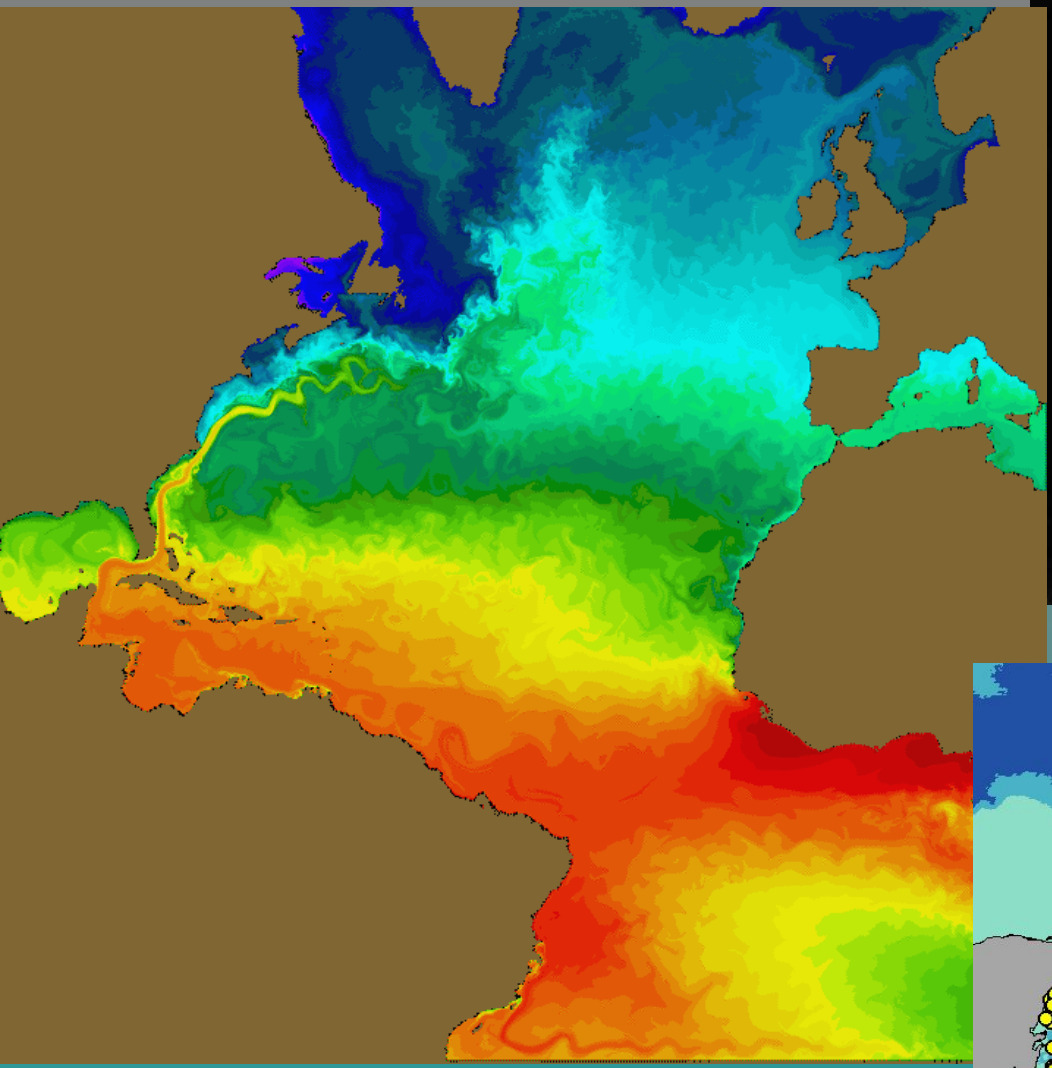


- What ***is*** the shape of the dispersal kernal, how do curves differ for various systems, species, and life histories?
- Over what distances are larvae typically dispersed?
- What are the ***implications*** of different kernals on the population dynamics and management of species?

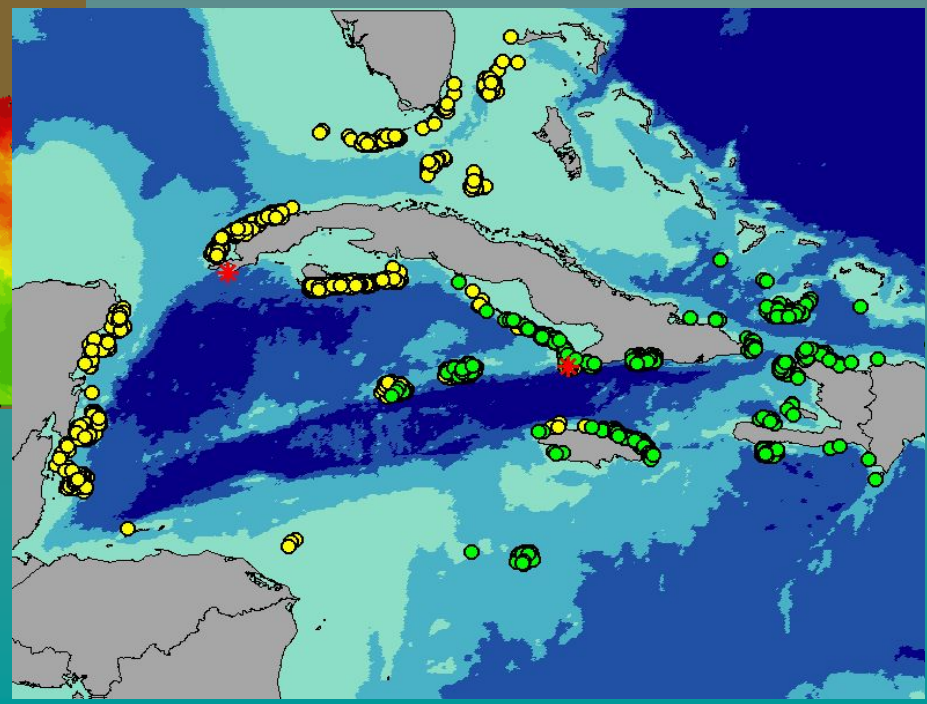
Biophysical Modeling Environment: Coupling Framework

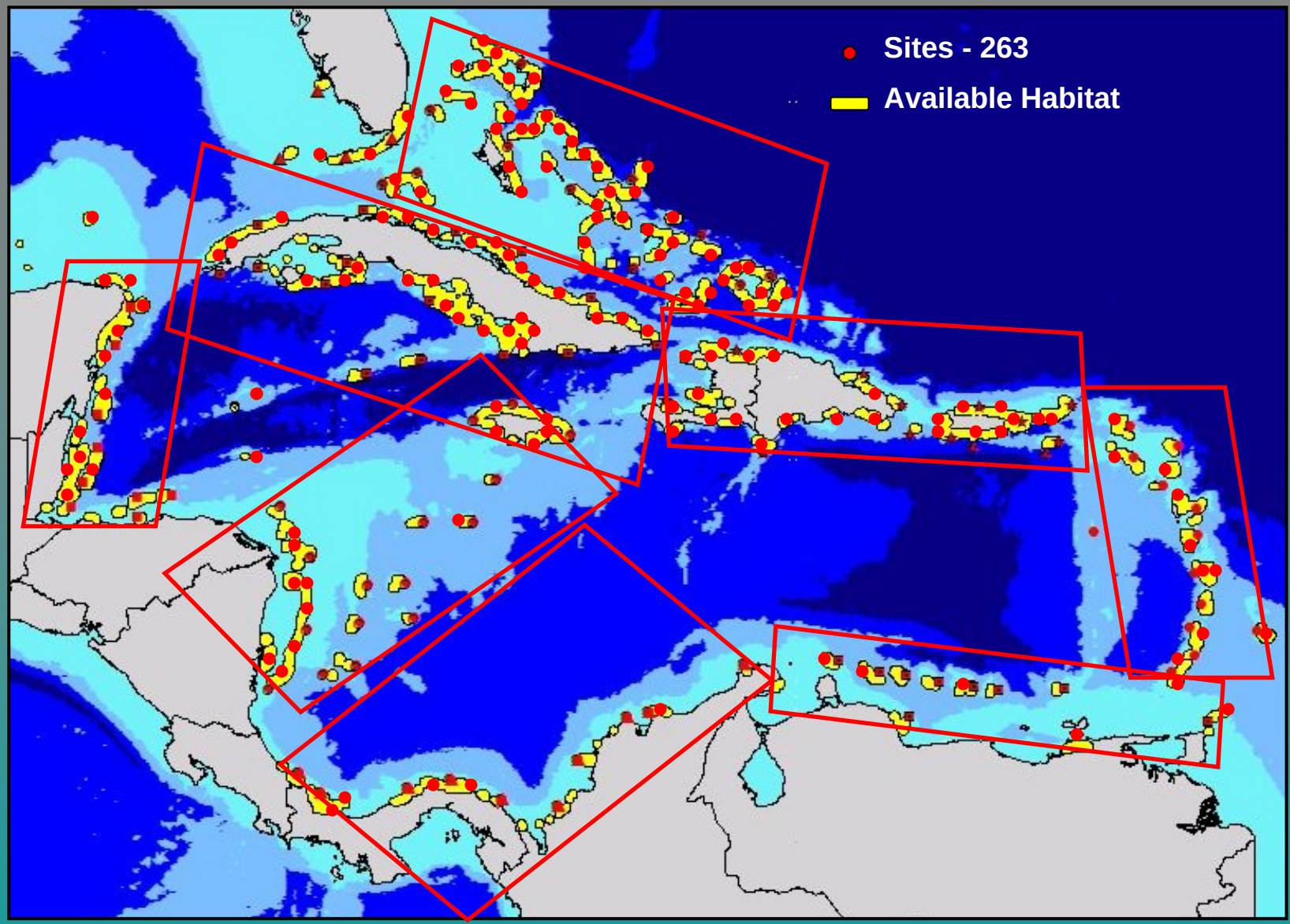


MICOM – Ocean circulation model



Larval dispersal



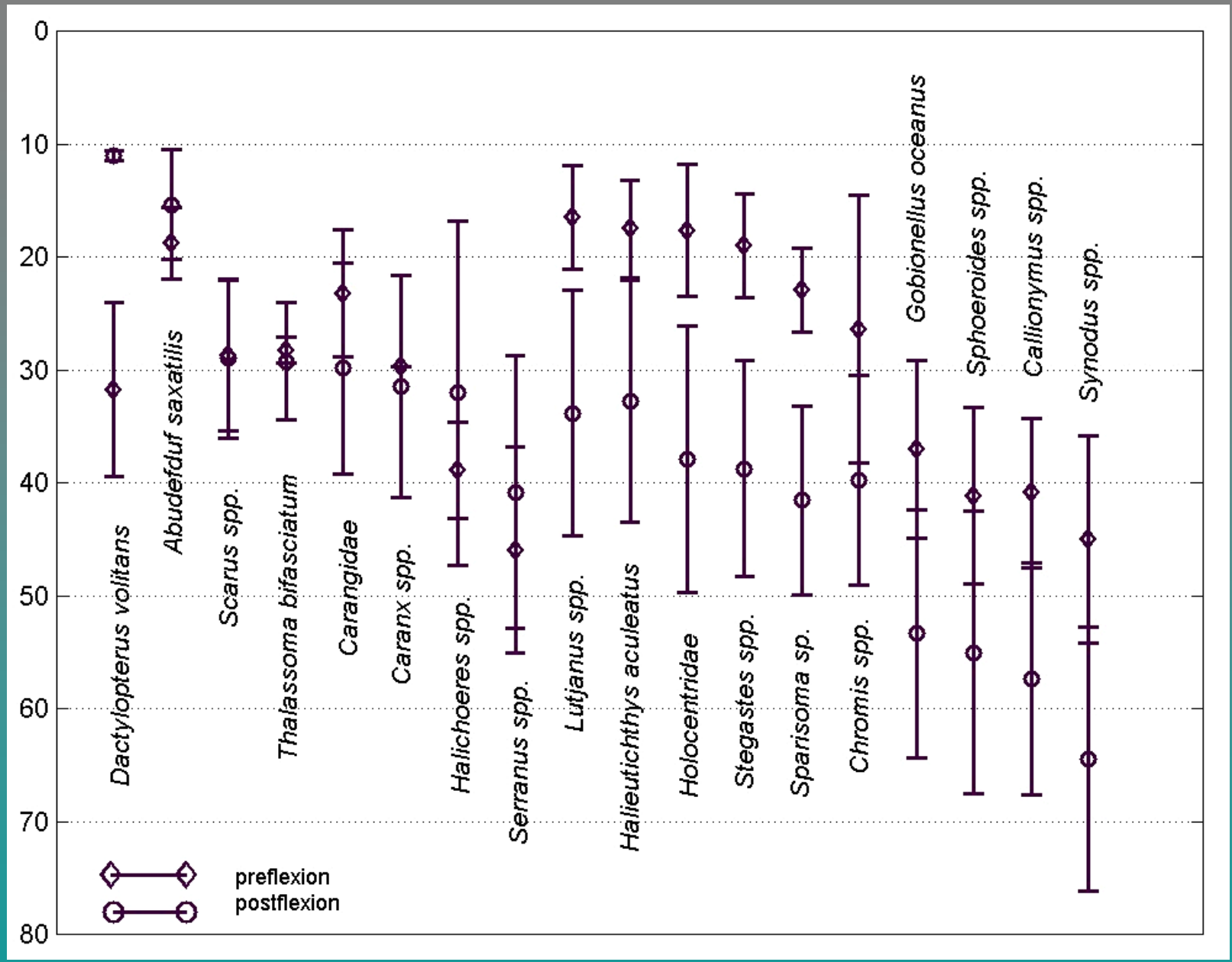

Sites - 263
Available Habitat

- *263 sites around Caribbean*
- *1000 larvae released per run*
- *Runs every 10 d/release site over 5 years*

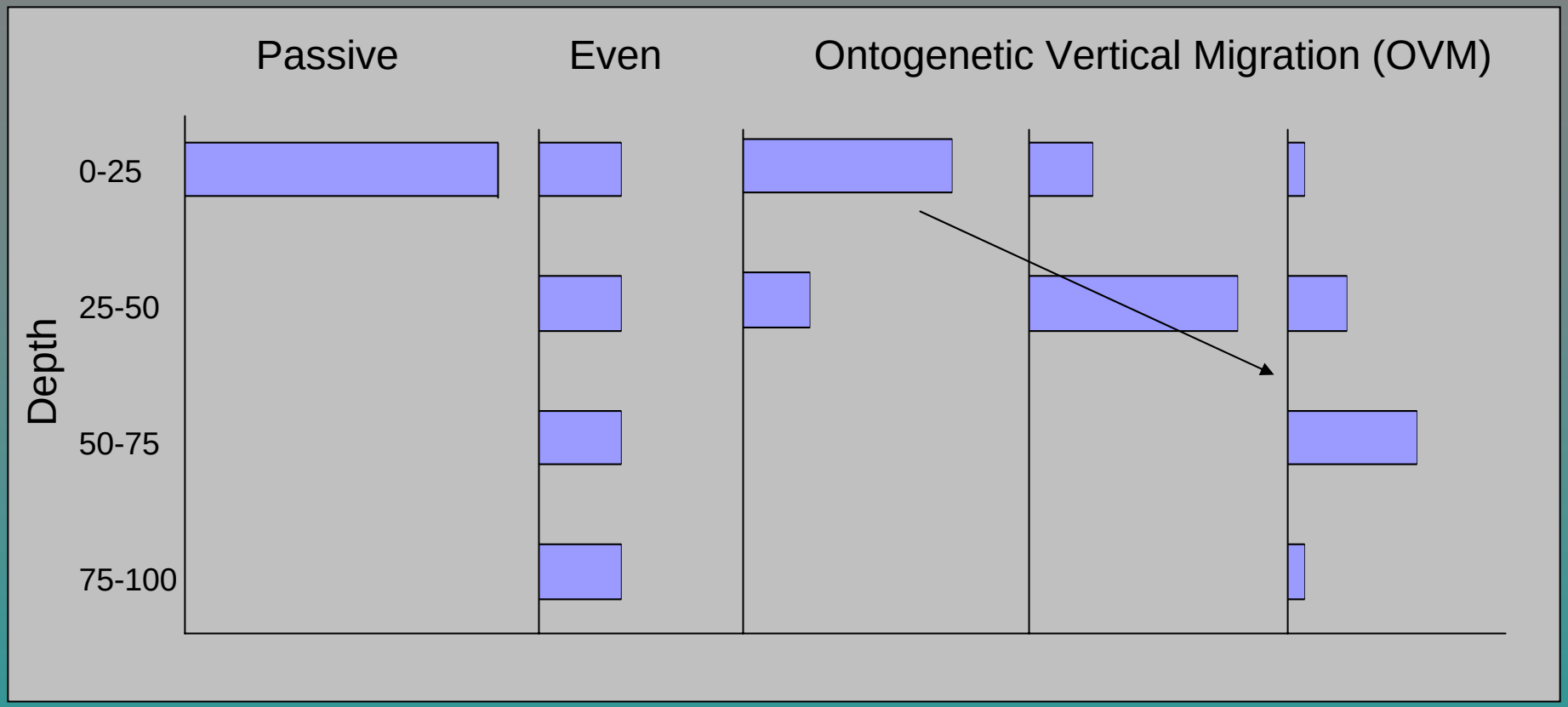
43 million trajectories (surviving virtual larvae)

310,000,000,000 eggs (pre-larval mortality)

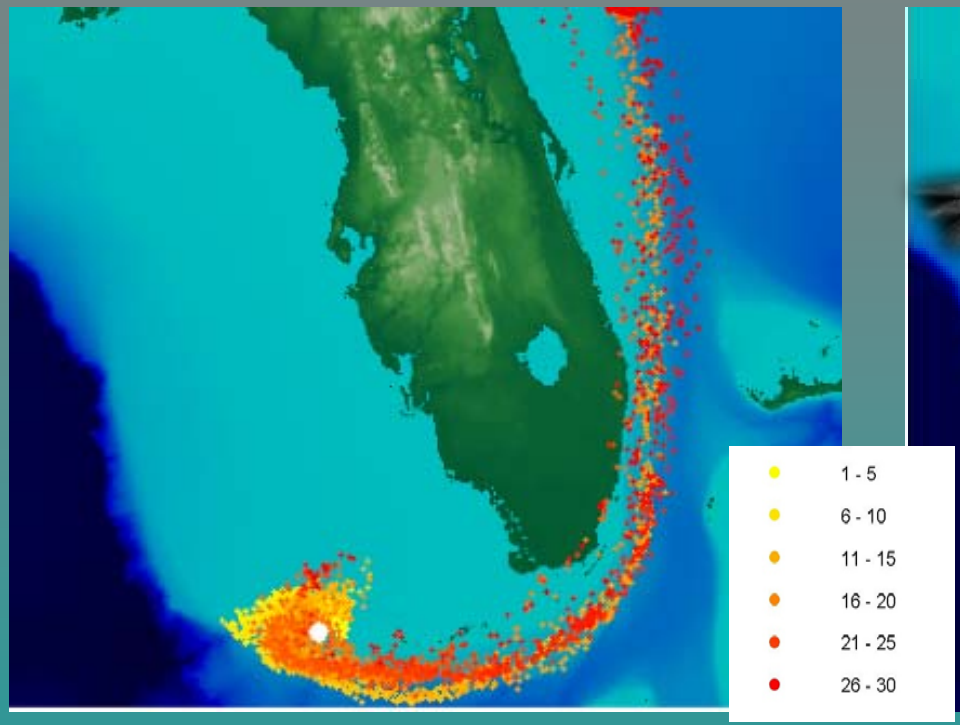
Vertical Distribution of larval fishes



Vertical Schemes



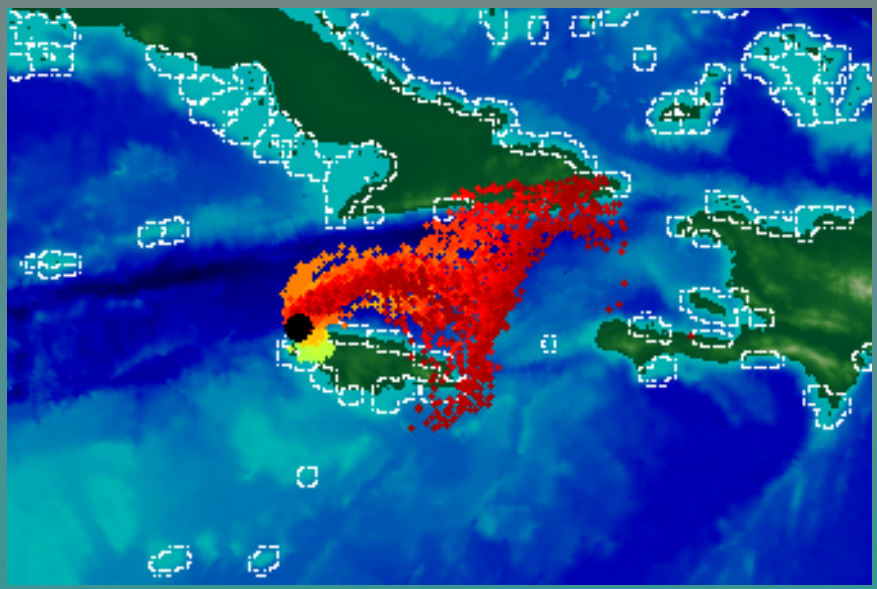
HYCOM 1/12 - Biophysical Offline Lagrangian Tracking System (BOLTS) daily output Passive transport vs larval transport with Ontogenetic Vertical Migration (OVM)



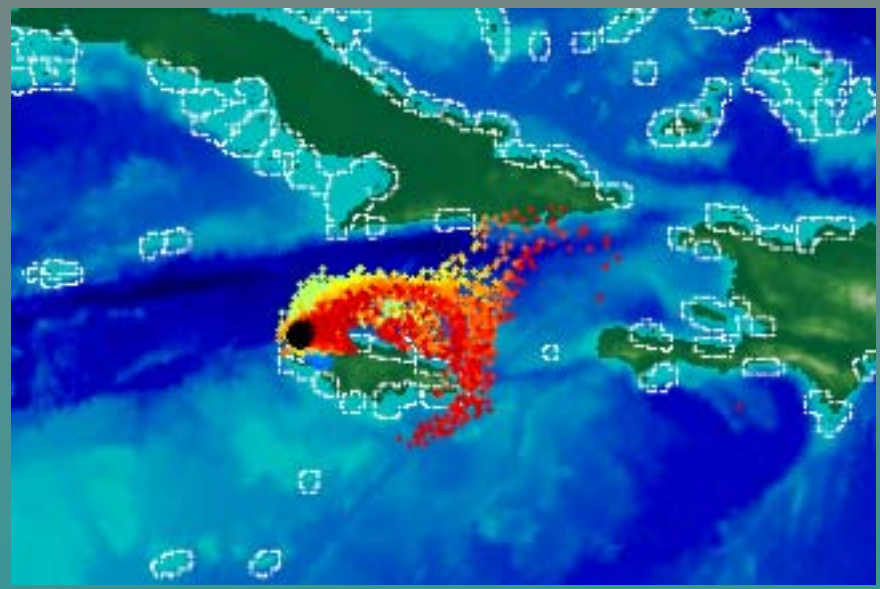
Dry Tortugas - Release April 1, 2004
Daily position of particles during a 30-day passive transport in the Florida Current
Recruitment to coral reef = 2%

Dry Tortugas - Release April 1, 2004
30-day active transport with OVM observed from the bicolor damselfish larvae
Recruitment to coral reef = 38%

HYCOM 1/12 - 2004
Passive transport vs
larval transport with Ontogenetic Vertical Migration (OVM)



Jamaica Montigo Bay - Release Aug 1
Daily position of particles during a 30-day passive transport in the Florida Current
Recruitment to coral reef = 15 %



Jamaica Montigo Bay - Release Aug 1
30-day active transport with OVM observed from the bicolor damselfish larvae
Recruitment to coral reef = 27 %

Estimation of Demographically-relevant Recruitment Rates

Demographically relevant recruitment rates = proportion of surviving larvae required to reach settlement site:

f (longevity, age structure, number of females, fecundity, and larval, juvenile and adult survival)

2 steps –

- estimate # recruits required to maintain constant population size
  - Age structure
  - Annual mortality rate

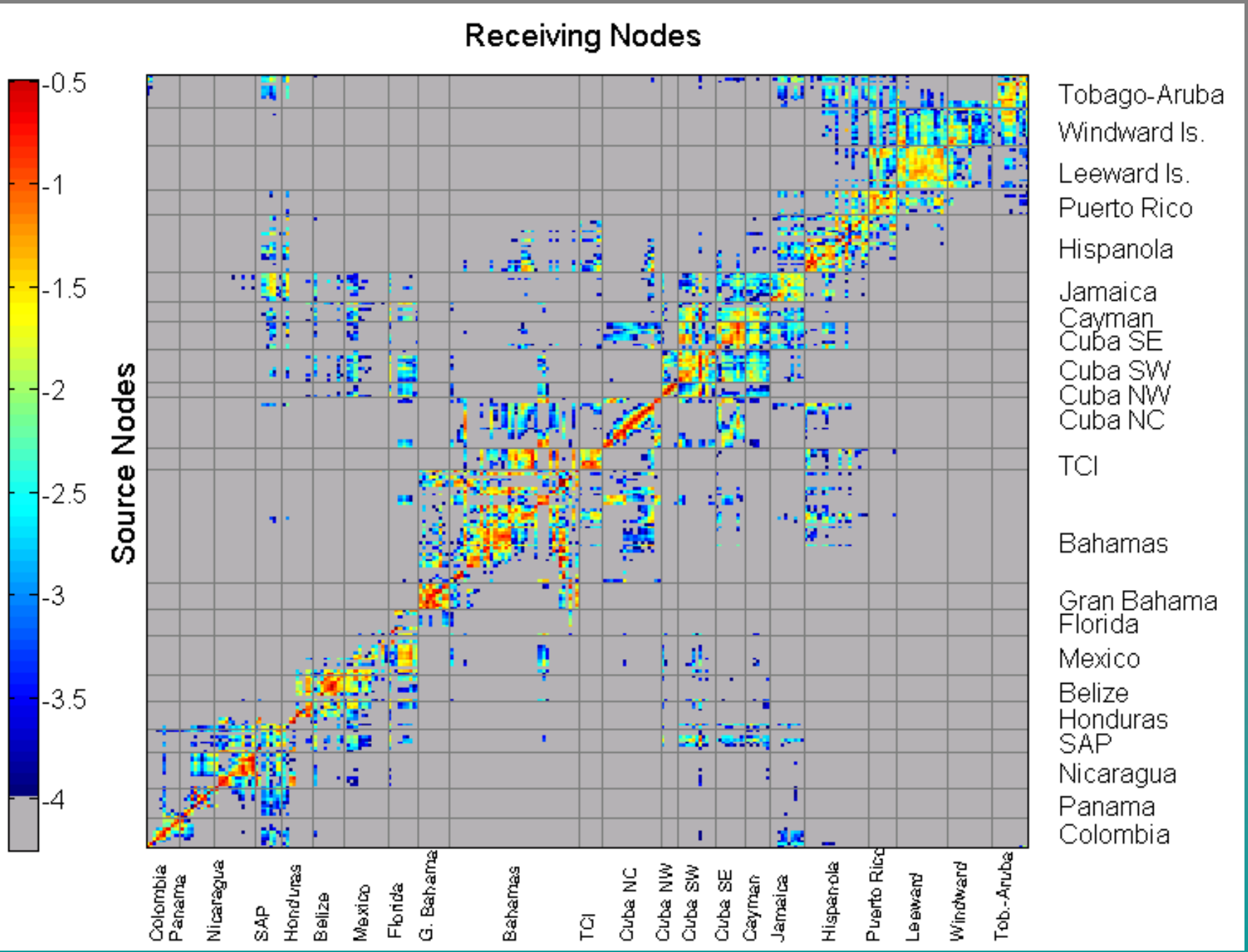
- Estimate standardized proportion spawned required to reach settlement
  - Age-specific fecundity
  - Larval durations
  - Larval mortality rates

Estimation of Demographically-relevant Recruitment Rates

Demographically-relevant recruitment rates as Proportion of Survivors:

Short-lived spp (e.g. gobies)	1.0
med.-lived spp (e.g. damselfish)	0.28
long-lived spp (e.g. snapper/grouper)	0.1

Range: $\text{Log}_{10} = 0$ to -1



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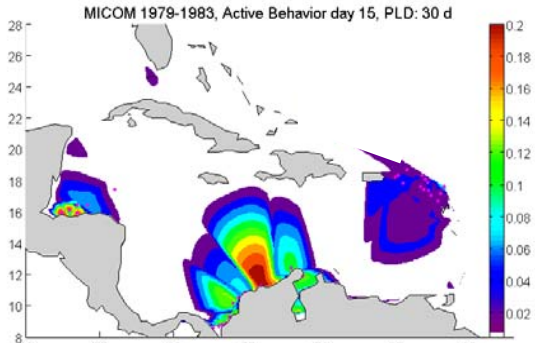
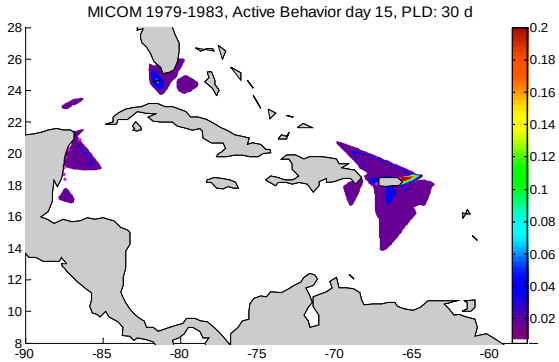
Dispersal Kernels by Regions - PLD 30 d, Active 15 d

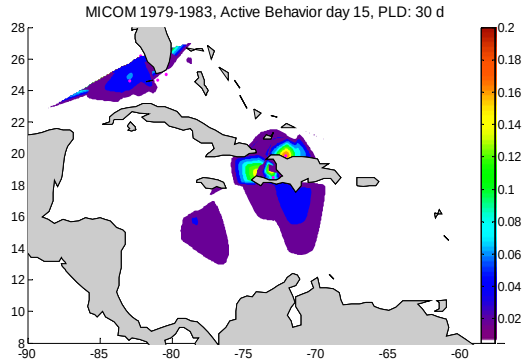
Leeward Is., Colombian Coast, Honduras Bay



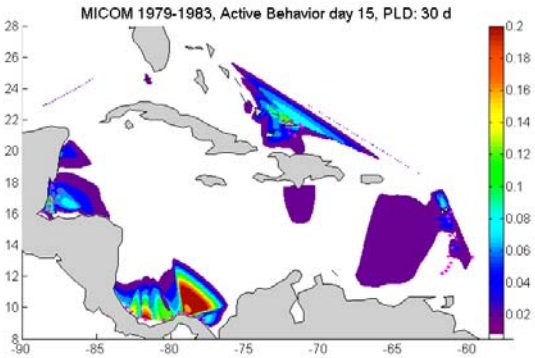
Mexico, Puerto Rico



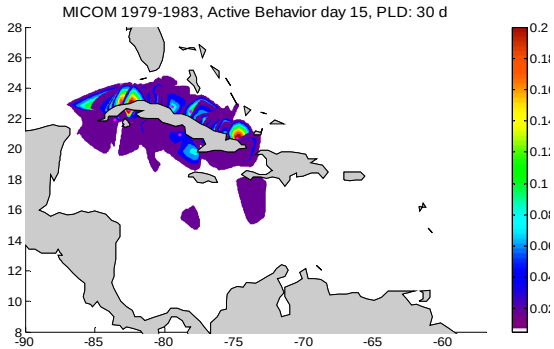
Florida, Haiti



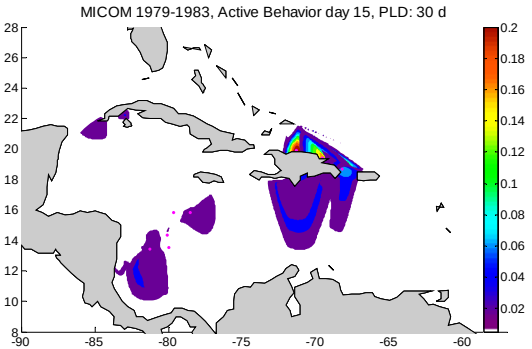
Belize, Panama Gyre, Windward Is., TCI



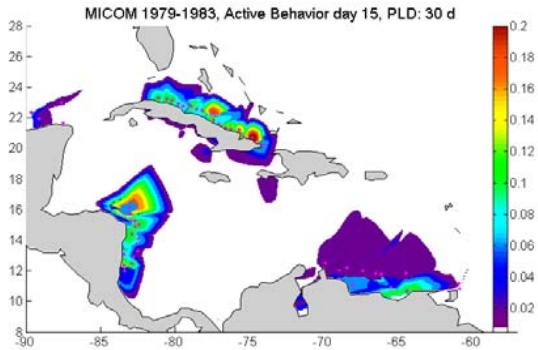
Cuba



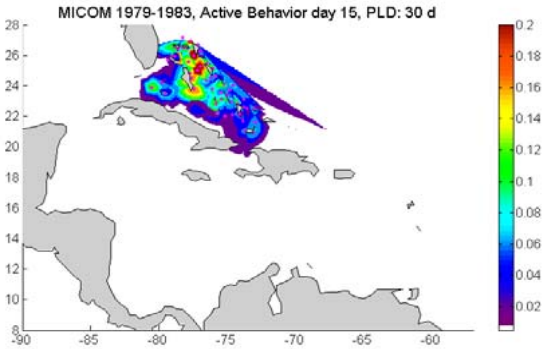
Dominican Rep., San Andres-Providencia



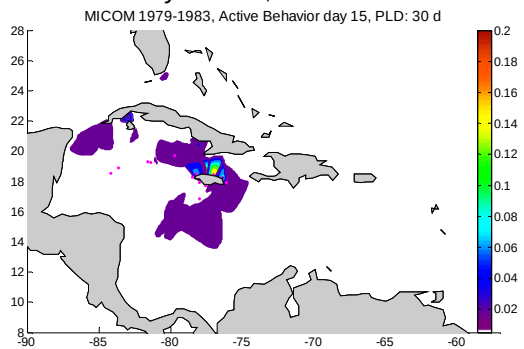
N Yucatan, NC Cuba, Nicaraguan Rise
Venezuelan Corridor



Bahamas



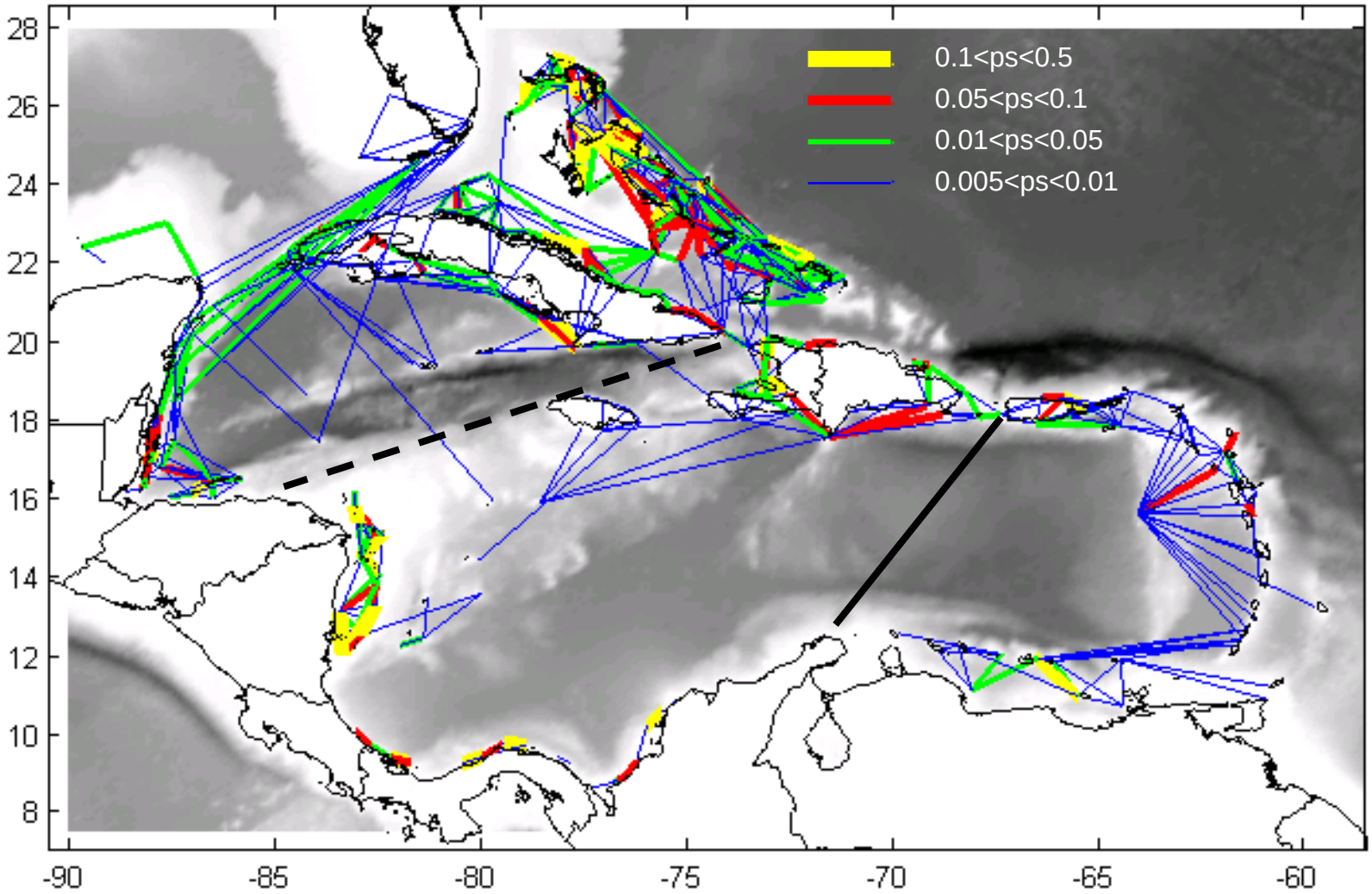
Cayman Is., Jamaica



Ecologically Relevant Dispersal Distances

Region	Total Recruit (prop. surv.)	Self Rt (% Tot. R)	Source Distance (km) for Recruitme		
			0.01	0.1	0.3
Caribbean	0.39	20.7	< 50	< 100	200
Bahamas	0.64	21.5	< 50	< 50	< 100
Panama Gyre	0.63	21.2	< 50	< 50	50
Haiti	0.45	26.9	< 50	< 50	< 150
Cuba	0.43	25.0	<50	<50	< 200
Greater Antilles	0.39	13.0	< 50	50	< 250
Belize	0.37	26.4	<50	< 50	100
Dominican Rep.	0.36	27.0	<50	50	300
Honduras	0.33	36.2	< 50	<50	150
Florida	0.33	14.9	< 50	300	950
Colombia Gyre	0.23	56.9	< 50	< 50	N/A
Lesser Antilles	0.23	12.9	< 50	100	N/A
Venezuela Corr.	0.22	16.4	< 50	150	N/A
Jamaica	0.22	24.4	< 50	100	N/A
Cayman	0.18	9.8	< 50	250	N/A
Mexico	0.17	9.0	< 50	250	N/A

Spatially Explicit Connectivity



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World Bank - GEF - Coral Reef Targeted Research project

NSF

e
ENVIRONMENTAL DEFENSE
finding the ways that work

Coral Reef
Targeted Research & Capacity Building for Management